PATENT SPECIFICATION 1,116,861

NO DRAWINGS.

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1,116,861

Date of filing Complete Specificati n: 30 Nov, 1964.

Applicati n Date: 23 Dec., 1963. No. 50733/63.

Complete Specification Published: 12 June, 1968.

Index at Acceptance:—H1 H(1, 2, 3A, 3C, 4, 6B, 8B); E2 A E19.

Int. Cl.:—H 01 f 1/08.

COMPLETE SPECIFICATION.

Improvements in and relating to Synthetic Plastic Compositions Capable of being Magnetised.

We, BAKELITE XYLONITE LIMITED, a British Company, of 27 Blandford Street, London, W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to synthetic plastic compositions that are capable of being magnetised, and is especially concerned with compositions which may be formed into flexible shaped articles.

Synthetic plastic compositions capable of being magnetised may be used for the manufacture of magnets of complicated shape, magnets which are required to conform to close tolerances, and magnets which must be flexible. Hence synthetic plastic magnets are used for refrigerator closures, door catches and in various toys. The known synthetic plastic compositions capable of being magnetised usually contain a finely divided filler material capable of being magnetised such as, for example, iron oxide, barium ferrite, strontium ferrite, or bismuth manganese, dispersed in a thermoplastic carrier. A high proportion of the composition is taken up by the filler in order that a magnet formed from the composition might have the necessary magnetic strength, and the proportion by volume of the filler may be 60—70% and by weight may be 85—95%, depending upon the density of the thermoplastic carrier. Articles made from such compositions tend to be either hard and brittle or soft and cheesy with little cohesive strength, and these poor physical properties have hitherto limited the applications to which synthetic plastic magnets may be put.

The thermoplastic carrier most commonly used for the manufacture of, for example, refrigerator closures, is based on polyvinyl chloride, but, when such a carrier is compounded with at least twice its weight of finely divided magnetic iron oxide the resultant product is hard and brittle and of little value. It is therefore usual to add a substantial quantity of a plasticiser to the composition, for example, equal weights of the carrier and the plasticiser may be used, but a product made from such a composition has little cohesive or tear strength and will break if bent through 180°. Moreover, the cost of the product is increased by the use of the plasticiser, and at the high concentrations used, the plasticiser is liable to exude from the product.

The ppresent invention provides a synthetic plastic composition capable of being magnetised, which comprises (1) copolymer of ethylene and vinyl acetate and/or a copolymer of ethylene and an alkyl acrylate, (2) a homopolymer of isobutylene and/or a copolymer formed from a monomer mixture containing a major proportion by weight of isobutylene, and (3) a major proportion by weight of the composition of a finely divided material that is capable of being magnetised. Preferably, the finely divided material is barium ferrite, strontium ferrite or manganese bismuth. The copolymer of ethylene and an alkyl acrylate is preferably a copolymer of ethylene and ethyl acrylate. The alkyl acrylate may be present in the monomer mixture used in preparing the copolymer in an amount within the range of from 2 to 25% by weight, preferably from 3 to 15% by weight, based on the weight of the copolymer. The vinyl acetate may be present in the monomer mixture used in the preparation of the copolymer of ethylene and vinyl acetate in an amount within the range of from 25 to

35% by weight based on the weight of the copolymer, the monomer mixture preferably containing about 28% by weight of vinyl acetate.

The copolymer formed from a monomer mixture containing a major proportion by weight of isobutylene is preferably a copolymer formed from a monomer mixture containing not less than 95% by weight of isobutylene and not more than 5% by weight of isoprene and/or styrene.

In a composition according to the present invention, the ratio by weight of the amount of the homopolymer and/or copolymer of isobutylene to the amount of component (1), the ethylene copolymer or copolymers, may be within the range of from 1:20 to 19:20, preferably within the range of from 2:10 to 7:10.

Advantageously, the amount of the finely divided material in the composition is within the range of from 70 to 96% by weight of the composition. The synthetic plastic composition advantageously comprises from 2 to 28% of a copolymer of ethylene and ethyl acrylate or of a copolymer of ethylene and vinyl acetate, from 2 to 10% of a homopolymer of isobutylene and from 70 to 96% of finely divided barium ferrite, the percentages being by weight calculated on the total weight of the composition.

The present invention also provides synthetic plastic articles capable of being magnetised and manufactured from a synthetic plastic composition according to the present invention.

The invention also provides a synthetic plastic magnet formed from a synthetic plastic composition according to the present invention.

Synthetic plastic compositions according to the present invention are particularly suitable for the manufacture of flexible magnetic strips. The term "flexible magnetic strip" is used in this specification to denote a strip of flexible magnetic material which can be bent through an angle of 180° without breaking and which has a high resistance to flex fatigue as indicated by the following simple test. A specimen 2 inches long, ½ inch wide and 0.014 inch thick is placed under a tension of 200 pounds per square inch and bent through an angle of 45° on each side of the unbent position at the rate of 120 cycles per minute. The material has a high resistance to flex fatigue if the specimen withstands at least 100 cycles before failure. A flexible magnetic strip made from a synthetic plastic composition according to the present invention may have a thickness within the range of from 0.005 to 0.06 inch.

Flexible magnetic strips according to the present invention may be used to attach mosquito netting to the frame of an open window in order to enable fresh air to enter whilst preventing mosquities, flies, wasps and other objectionable insects from entering or to attach transparent sheet to window frames which are not glazed in order to provide temporary panes. Other applications of the flexible magnetic strip include refrigerator closures (in which a superposed soft gasket need not be used), thick flat rings serving as pole magnets for centering television tube beams, door catches, toys and closures for bag-like containers (as described in our copending Application No. 50734/63 Serial No. 1,116,862). The strip may be attached to the vertical edges of curtains by an adhesive or by sewing in order to prevent the curtains from separating when drawn together, so avoiding the need for overlapping curtain runners. Magnetic strips may also be used in place of zip fasteners in clothing, especially baby garments. Other uses for magnetic strip include attaching papers to vertical metal surfaces, forming advertising displays, preventing the sliding of telephones and similar objects on metal tables, and holding kitchen utensils on a vertical surface.

The flexible magnetic strip according to the invention may also be used for attaching sheet material to objects for general heat and/or sound insulation by means of a sealed air space. Advantages of such an arrangement are that the sheet material is readily detachable and that the method of attachment provides a good seal. The sheet material may be rigid or flexible, and may be clear, translucent or opaque. The material may be manufactured from plastic, rubber, glass, metal, paper or fabric. As an example of this use of the flexible magnetic strip there may be mentioned double glazing by means of transparent plastic sheeting.

A spnthetic plastic magnet (including a flexible magnetic strip) according to the present invention may be produced by a process which comprises compounding together at a raised temperature (1) a copolymer of ethylene and vinyl acetate and/or a copolymer of ethylene and an alkyl acrylate, (2) a homopolymer of isobutylene and/or a copolymer formed from a monomer mixture contining a major proportion by weight of isobutylene, and (3) a major proportion by weight of the composition of a finely divided material capable of being magnetised, to form a composition, cooling the composition, forming the composition into the desired shape and subjecting the composition to a strong electromagnetic magnetising field. The composition may be formed into the desired shape at an elevated temperature, in which case the composition may be subjected to the magnetising field whilst the desired shape is at a temperature at or close to the said elevated temperature or after the shape has cooled to room temperature.

Synthetic plastic articles and magnets (in-

cluding flexible magnetic strips) made in accordance with the present invention may be easily welded to polyethylene and other polyolefines by heat sealing or high frequency welding. The also have a good affinity for adhesives which permit a permanent bond to be made to other synthetic rubbers and plastics and to fabrics and paper-based materials.

The following Examples illustrate the invention, the parts and percentages being by weight:—

EXAMPLE 1

A composition containing 100 parts of an ethylene/ethyl acrylate copolymer sold by Bakelite Ltd. under the designation DPD 6169 (the copolymer having been prepared from a monomer mixture containing an amount of ethyl acrylate in the range of from 3 to 15% of the mixture), 60 parts of a homopolymer of isobutylene, and 907 parts of Magnadur (Registered Trade Mark) M1 (a barium ferrite) was formed on a twin roll mill at a temperature within the range of from 85 to 95°C. The homogeneous mass produced was cooled, chipped and extruded at temperatures of 100°, 145° and 140°C to form a strip one inch wide and 0.014 inch thick. The strip was allowed to cool and then magnetised, and the strip could be bonded to polyolefines by the use of conventional heat sealing equipment. The strip responded to the flexibility tests given above in the manner shown in Table 1.

By way of comparison, a composition based on polyvinyl chloride was prepared from:

90 parts of Breon (Registered Trade Mark) 112, a suspension polymer of vinyl chloride having a "K" value of about 70.

40 parts of dioctyl phthalate (a plasticiser)

2.5 parts of Ferroclere (Registered Trade Mark) 1234, a cadmium/barium stabiliser

2.5 parts of Wax OP, a modified montan wax having a melting point of 102—106°C, specific gravity of 1.03 and acid number 10—15.

950 parts of Magnadur M1.

The composition was fluxed on a twin roll mill at a temperature of about 135—140°C, cooled, chipped, and extruded to form a strip at temperatures of 120, 145 and 150°C. The strip was very brittle and cracked when bent through an angle of 180°. The results of flexibility tests are also shown in Table 1.

By way of further comparison, a composition containing 150 parts of the copolymer of ethylene and ethyl acrylate and 850 parts of Magnadur M1 was processed to form a strip by a similar method to those described above. The strip so formed was not as brittle as the polyvinyl chloride-based strip, but it also cracked when bent through an angle of 180°. The result of flexiblility tests are also shown in Table 1.

EXAMPLE 2

A composition containing 100 parts of a copolymer of ethylene and vinyl acetate (the monomer mixture from which the copolymer was produced containing 28% vinyl acetate), 60 parts of a homopolymer of isobutylene, and 907 parts of Magnadur M1 was processed by the method described first in Example 1 to form a strip. The strip could be bent through an angle of 180° without cracking, and could be welded to polyethylene sheeting without difficulty. The results of the flexibility tests are given in Table 1.

By way of comparison, a similar composition which did not contain the homopolymer of isobutylene was processed to form a strip. This strip was very brittle, and the results of the flexibility tests are shown in Table 1.

Table 1

Composition	Plex life cycles to failure	Tensile strength pounds per square inch	180° bend test
Example 1	6726	710	passes
Polyvinyl chloride comparison ...	0	1,600	fails
Ethylene-ethyl acrylate copolymer comparison	62	1,360	fails
Example 2	154	640	passes
Ethylene-vinyl acetate copolymer comparison	0	1,260	fails

The method used to magnetise the strips so formed in the above Examples comprised arranging a six inch length of the strip over multiple pairs of North and South poles of an electromagnet, the electromagnet being energised by the discharge of a large capa-

citor through the coil of the electromagnet. A six inch length of the strip was thus magnetised at each discharge, and the strip was then advanced six inches and th capacitor recharged. It is to be clearly understood that other suitable methods of magnetising the strips could be employed.

EXAMPLE 3

The composition according to the present invention that is described in Example 1 was formed on a twin roll mill at a temperature within the range of from 85 to 95°C. The homogeneous mass produced was cooled, chipped and extruded at temperatures of 100°, 145°, and 140°C. to form pellets of 1/8 inch diameter. These pellets were then fed to an injection moulding machine which formed bars 3 inches long, ½ inch wide, and ¼ inch thick. The temperatures along the barrel of the machine ranged from 170°C. at the back to 210°C. at the nozzle, and the mould was maintained at 50°C. The bars so formed were then passed through a strong magnetic field to form bar magnets.

EXAMPLE 4

A composition containing 100 parts of Bakelite DQDE 1868 (an ethylene-vinyl acetate copolymer), 60 parts of a homopolymer of isobutylene and 907 parts of magnadur M4 was processed by the method described in Example 1 to form a strip one inch wide, 0.014 inch. thick. This strip could be bent through 180° without cracking and had the following physical properties:—

Flex life (cycles to failure) ...	4300
Tensile strength p.s.i. ...	680
Elongation at break % ...	135
Specific gravity	3.08

WHAT WE CLAIM IS:—

1. A synthetic plastic composition capable of being magnetised, which comprises (1) a copolymer of ethylene and vinyl acetate and/or a copolymer of ethylene and an alkyl acrylate, (2) a homopolymer of isobutylene and/or a copolymer formed from a monomer mixture containing a major proportion by weight of isobutylene, and (3) a major proportion by weight of the composition of a finely divided material that is capable of being magnetised.

2. A synthetic plastic composition as claimed in claim 1, wherein the finely divided material is barium ferrite, stontium ferrite or manganese bismuth.

3. A synthetic plastic composition as claimed in claim 1 or claim 2, wherein the copolymer of ethylene and an alkyl acrylate is a copolymer of ethylene and ethyl acrylate.

4. A synthetic plastic composition as claimed in any one of claims 1 to 3, wherein the copolymer of ethylene and an alkyl acrylate is prepared from a monomer mixture containing the alkyl acrylate in an amount within the range of from 2 to 25% by weight, based on the weight of the copolymer.

5. A synthetic plastic composition as claimed in claim 4, wherein the amount of alkyl acrylate in the monomer mixture is within the range of from 3 to 15% by weight, based on the weight of the copolymer.

6. A synthetic plastic composition as claimed in any one of claims 1 to 5, wherein the copolymer of ethylene and vinyl acetate is prepared from a monomer mixture containing the vinyl acetate in an amount within the range of from 25 to 35% by weight, based on the weight of the copolymer.

7. A synthetic plastic composition as claimed in claim 6, wherein the monomer mixture contains about 28% by weight of vinyl acetate, based on the weight of the copolymer.

8. A synthetic plastic composition as claimed in any one of claims 1 to 7, wherein the copolymer formed from a monomer mixture containing a major proportion by weight of isobutylene is a copolymer formed from a monomer mixture containing not less than 95% by weight of isobutylene and not more than 5% by weight of isoprene and/or styrene.

9. A synthetic plastic composition as claimed in any one of claims 1 to 8, wherein the ratio by weight of the amount of the homopolymer and/or copolymer of isobutylene to the amount of component (1) is within the range of from 1:20 to 19:20.

10. A synthetic plastic composition as claimed in claim 9, wherein the said ratio is within the range of from 2:10 to 7:10.

11. A synthetic plastic composition as claimed in any one of claims 1 to 10, wherein the amount of finely divided material in the composition is within the range of from 70 to 96% by weight of the composition.

12. A synthetic plastic composition as claimed in claim 1, which comprises from 2 to 28% of a copolymer of ethylene and ethyl acrylate or of a copolymer of ethylene and vinyl acetate, from 2 to 10% of a homopolymer of isobutylene, and from 70 to 96% of finely divided barium ferrite, the percentages being by weight calculated on the total weight of the composition.

13. A synthetic plastic article capable of being magnetised and manufactured from a synthetic plastic composition as claimed in any one of claims 1 to 12.

14. A synthetic plastic magnet formed from a synthetic plastic composition as claimed in any one of claims 1 to 12.

15. A flexible magnetic strip (as hereinbefore defined) manufactured from a syn-

thetic plastic composition as claimed in any on of claims 1 to 12.

16. A flexible magnetic strip as claimed in claim 15 having a thickness within the range of from 0.005 to 0.06 inch.

17. A process for the manufacture of a synthetic plastic magnet or flexible magnetic strip, which comprises compounding together at a raised temperature (1) a copolymer of ethylene and vinyl acetate and/or a copolymer of ethylene and an alkyl acrylate, (2) a homopolymer of isobutylene and/or a copolymer formed from a monomer mixture containing a major proportion by weight of isobutylene, and (3) a major proportion by weight of the composition of a finely divided material capable of being magnetised, to form a composition, cooling the composition, forming the composition into the desired shape and subjecting the composition to a strong electromagnetic magnetising field.

18. A process as claimed in claim 17, wherein the composition is formed into the desired shape at an elevated temperature.

19. A process as claimed in claim 18, wherein the composition is subjected to the magnetising field whilst the desired shape is at a temperature at or close to the said elevated temperature.

20. A process as claimed in claim 18, wherein the composition is subjected to the magnetising field after the desired shape has cooled to room temperature.

21. A synthetic plastic composition capable of being magnetised as claimed in claim 1 and substantially as described in Exampl 1, Example 2 or Example 4 herein.

22. A flexible magnetic strip as claimed in Claim 15 produced from a composition substantially as described in any one of Examples 1, 2 and 4 herein by a process carried out substantially as described in the Example.

23. A bar magnet substantially as described in Example 3 herein.

24. A process for the manufacture of a flexible magnetic strip as claimed in claim 17, which process is carried out substantially as described in any one of Examples 1, 2 and 4 herein.

25. A process for the manufacture of a bar magnet, which process is carried out substantially as described in Example 3 herein.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1968.
Published at The Patent Office, 25 Southampton Buildings, Loffdon, W.C.2,
from which copies may be obtained.